that a wide field of profitable research and future mining operations has been revealed by Mr. Edelstein's skilled labours.

No. 18 of the reports of the Zoological and Zootomical Cabinets of St. Petersburg University forms a very interesting report by Mr. K. M. Derjugin on the Murman Biological Station, a centre of activity for six years in the Kola gulf and peninsula. Previously, the station was on the Solovetsk Islands, and the band of naturalists came into contact, not free from misunderstanding, with the authorities of the famous monastery. The station consists of a main building with laboratories, library, museum, and aquarium; living quarters; houses for attendants; shed and dock, with ice-house; engine-house and workshop; pavilion above a granite basin; and small harbour, with fresh- and salt-water channels. The *Orca*, a small sailing vessel of Norwegian type, is used for cruising and exploration. The fauna resembles that of Spitsbergen, especially on its western side. The journey from Archangel, we learn, presents great interest and variety for the naturalist. In his enumeration of species of plankton, Mr. A. K. Linko remarks that a vast amount of material in the northern seas has not yet been studied, and promises future reports. The work contains tables of observations, records of temperature, plans and sketches, and a library catalogue.

Mr. V. V. Markovitch has described a botanical excursion from Ossetia to Colchis, including the sources of the rivers Ardon and Rion. His first chapter opens

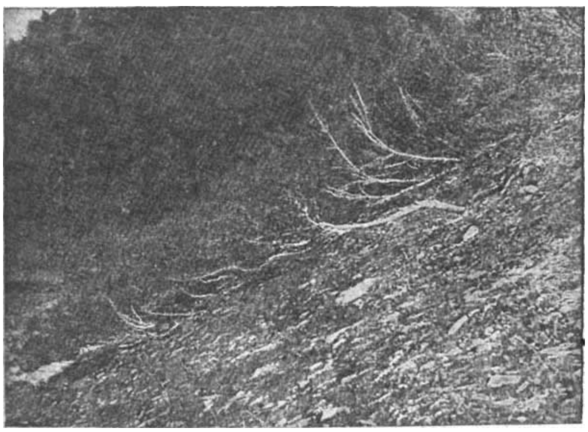

FIG. 2.—Wood growing horizontally out of permanent snow mounds.

with an account of the great mountain range at different seasons, and of the gaudy sun-tints. The people of Ossetia, whose characteristics are respectively modified by proximity to Georgians or Kabardians, are generally grouped under the heads of Irontsi, Tualtsi, Digortsi, and Tagaurtsi, the central point being Alagir. As it was known that this region possessed silver-lead ore, and the Tsar Nicholas I. desired that the Russians should depend upon their own resources for lead in time of war instead of upon imports, this mining centre was established under the direction of the engineer Ivanitzky. This energetic official also started a nursery and fruit garden, the success of which has been so marked that the term "Alagirsky" denotes the highest type of fruit throughout the Caucasus. Passing along the Ossetian military road, traces of every geological period may be observed, including Palæozoic slates, but fossils are rare. Alagir itself is on the site of a huge glacier from the main crest of the Caucasus. Long experience convinced Mr. Markovitch that there is no marked difference between the northern and southern slopes of the Caucasus, but a gradual transition, and having received material support from the highest botanical authorities he was encouraged to study transitional forms. The most convenient time of year for exploration of the Ossetian mountains appears to be the end of July and the beginning of August, though botanists would need to go a little earlier. Throughout Ossetia sacred trees are found, into which pilgrims throw offerings of money and other gifts. This pagan survival is adapted to Christian saints' days, especially to the festival of the popular St. George, celebrated in November. A main conclusion of Mr. Markovitch's survey is that the differences between people living side by side on a limited area are greater than those in the flora, while in Russia the contrary is the case. Ossetians and Imeritians, who live together, are entirely distinct, while there is much similarity in neighbouring peoples along European frontiers. Contrary to former suppositions, the flora of the Colchis region varies very slightly from that of the northern Caucasus.

THE TEMPERATURE OF THE NORTH SEA.[1]

IN a Blue-book just published dealing with hydrographical work done in connection with the International Investigation of the North Sea, I have included a paper on some methods and results of hydrographical investigation, or, as it might perhaps have been more correctly termed, on some methods of representing hydrographical results.

We have from the work of our own vessel, the *Goldseeker*, quarterly observations at numerous stations in the northern part of the North Sea, and also monthly or six-weekly observations at some twenty other stations off the east coast of Scotland as far to the eastward as 1° east. At these stations, some fifty in all, we have observations at all depths, both as to temperature and to salinity. In addition to this work of our own, we receive from a large number of passenger captains frequent observations as to temperature and a smaller number of samples for the determination of salinity, taken at the

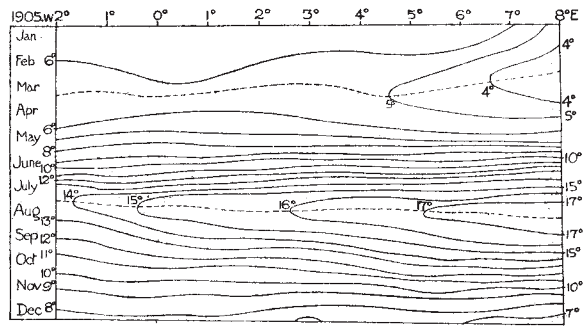

FIG. 1.

surface along many important routes crossing the North Sea. In the present paper temperature-phenomena alone are dealt with, and the results are based mainly upon our own work with but little attempt as yet to include or correlate the work of our foreign colleagues.

From a large number of observations such as we receive, from our own vessel and from the captains of liners—observations made at varying dates, and, in the case of the voluntary observations, at shifting points along particular lines—it is necessary in the first place to obtain, by interpolation, approximate data for given dates and localities. These data may then be diagrammatically represented in various ways.

Fig. 1 is a diagram of surface temperatures on the route from Leith to Hamburg, from January to December, 1905. It is constructed on a method devised some sixty years ago by Lalanne. The coordinates are time and distance along the given line, and over these coordinates are superposed contour lines, or "isopleths," representing temperature. It will be seen that from this diagram we can read at a glance many things; we see, for instance, that in early summer and late autumn there is little or no difference of temperature all the way, while, on the other hand, about March the sea gets gradually colder and about August gradually hotter as we travel eastward towards the

[1] Abstracted from the Second Report (Northern Area) on Fishery and Hydrographical Investigations in the North Sea and Adjacent Waters, 1904–1905 [Cd. 3358]. (1907.)

German coast. We easily see the extent of difference in seasonal range of temperature, which near our own coast runs from less than 6° C. to more than 13° C., at 2° east

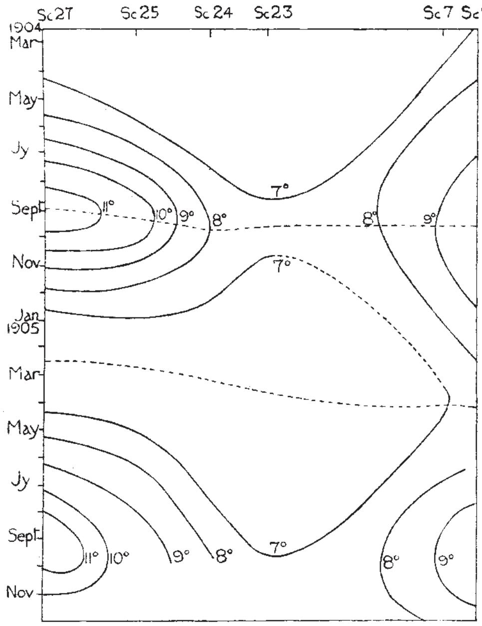

FIG. 2.

from less than 6° C. to more than 15° C., and off the German coast from less than 4° C. to more than 17° C. We notice next how comparatively slow are the changes of temperature when near the minimum in winter and the maximum in summer, and how rapid in spring and autumn when near the middle of the rise and fall, and we also perceive that the fall takes place somewhat slower than the rise, for the isopleths are less crowded in autumn than in spring. Lastly, we may discern that lines joining the cusps of the closed curves, in other words, the lines of minimum and maximum, tend to run somewhat obliquely across the chart, and that the maximum at least is definitely later as we approach the Continental coasts. Similar charts for various other routes show essentially the same phenomenon, and those drawn from the Scottish coast in the direction of Norway tend to show the influence of land at both ends of the route, the range of temperature being least in the middle.

Similar diagrams may be drawn for any given depth, and Fig. 2 is so drawn for a depth of 100 metres on a line from Buchan Deep, near Aberdeen, to the Viking Bank between Shetland and Norway. In this diagram we see that as we leave the coast the temperature-isopleths diminish rapidly in number, until in the neighbourhood of our station xxiii. (about 59° 40′ N., 0° 40′ E.) the seasonal change is only from something less to something more than 7°; but as we go further north we come again to a region of larger temperature variations, where the maximum is considerably higher and the minimum not quite so low. We notice also a retardation of dates, the maximum not being attained until well on in September.

Another series of diagrams, of a kind that has been more frequently employed, and notably by Dr. H. R. Mill in his work on the Clyde sea area, shows temperature plotted by means of isopleths over coordinates representing time and depth. While the former diagrams showed temperature changes along a line of stations during successive months, but for one depth only, these diagrams show the changes at all depths during successive months, but at one point of space only.

These and other methods of representing sea temperatures by means of diagrams may be supplemented by the use of empirical formulæ. The rise and fall of surface temperature at a given point is a very simple wave that can be suitably expressed as a sine-curve. In the periodic temperature-function

$$f(\theta)=A_0+A_1 \sin(\theta+e_1)+A_2 \sin(2\theta+e_2);$$

&c., θ is an angle increasing in proportion to the time, A_0, A_1, A_2 are constants expressed in degrees centigrade, and e is a phase angle of which each degree signifies approximately one day in advance or arrear of our starting point, namely (since we are dealing with monthly means), January 15. If we submit an annual series of temperature observations to harmonic analysis, we find that the first sine-factor differs but little from the actual curve, while the third and following factors are entirely negligible. If we deal with mean temperatures at a given point over several years, we find the simple sine-formulæ still more closely applicable. Thus, for the surface temperatures at Abertay, taking the mean of ten years, 1893–1903, we obtain the formula $f(\theta)=8{\cdot}43-4{\cdot}32 \sin(\theta+60°)$, and find that results calculated from this formula for the middle points of the successive months differ in no case by so much as half a degree centigrade, and by a mean difference of only one-fifth of a degree centigrade, from the means of the observed temperatures for the said months. If we were to apply the next factor of our harmonic formula $[+0{\cdot}29 \sin(2\theta+49°)]$ we should obtain calculated results showing a maximum discrepancy from observation of about a quarter of a degree, and a mean discrepancy of one-tenth of a degree.

After repeated trials of this kind we come to the conclusion that the sine-formula is a safe representation of the annual wave of temperature change. That it is a highly convenient one is obvious, for, in the first place, it gives us at a glance the three essential factors of the phenomenon, the mean temperature (A_0), the range or half-range of temperature (A_1), and the phase (e_1), which last we may briefly describe as the mean retardation of maximum and minimum. Furthermore, it enables us to compare these three factors very easily for a series of adjacent stations or for successive years. Thus if we work out our formula for points a degree of longitude apart on the route from Leith to Hamburg we obtain a table of which the following is a part:—

Table of Harmonic Constants for Surface Temperatures. Leith to Hamburg.

Long.	1904 A_0	1904 A_1	1904 e_1	1905 A_0	1905 A_1	1905 e_1
°			°			°
W. 2	8·90	4·18	51	8·86	3·07	56
1	9·20	4·18	50	9·24	3·09	56
0	9·48	4·39	51	9·55	4·24	56
E. 1	9·45	4·49	52	9·62	4·50	59
2	9·45	4·88	51	9·62	4·70	61
3	9·50	5·47	52	9·62	5·10	62
4	9·70	5·70	49	9·76	5·45	61
5	9·81	5·60	48	9·98	5·73	58

This orderly succession of constants may then anew be transferred to diagrams, as in Fig. 3. Similar data may

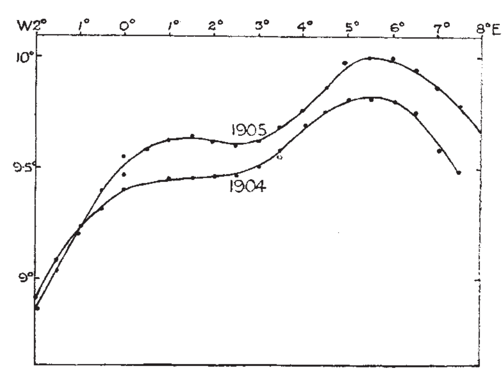

FIG. 3.

also be transferred to charts, of which a series is printed in the report.

Lastly, if it be granted that a sine-curve approximately

represents the actual succession of temperatures, we may modify our diagram of the annual wave by substituting for it a circle (Fig. 4), on which time and temperature may be read together. The centre of the circle is at a height above the base-line proportionate to the mean temperature, the radius is proportionate to the half-range, and when we shall have marked upon the circle a date-

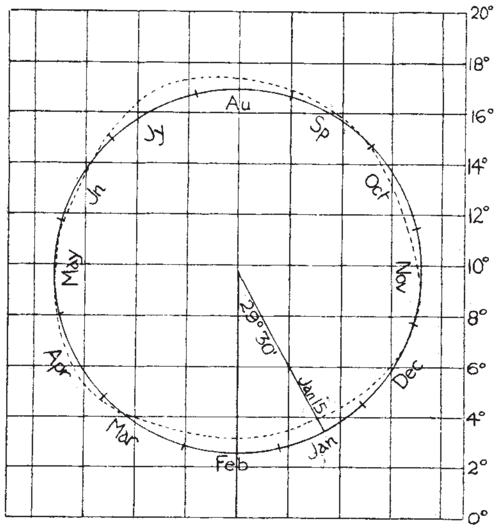

FIG. 4.

mark having reference to the phase, the temperature at a given date will be proportional to the perpendicular that falls on the base from a corresponding point of the circle. By superposing a number of such circles, or, better still perhaps, by combining them at proportionate distances in a solid model, we may represent all the various changes from point to point.

D'ARCY W. THOMPSON.

MAYA HIEROGLYPHS.[1]

BY way of encouraging the study of ancient documents having reference to the early history of the Mayas, the museum committee on Central American research purpose publishing translations of the more important papers that have appeared in connection with the deciphering of the Maya hieroglyphs. The most recent issue of this series is a translation of Dr. Förstemann's commentary on the Maya MS. in the Royal Library of Dresden, generally known as the Dresden Codex. The figures of the original manuscript may be known to students from the admirable reproductions due to Lord Kingsborough (London, 1831), and for the proper appreciation of the value of Förstemann's commentary, these plates or some other facsimile should be consulted. Without such assistance Dr. Förstemann admits that his description is of little value, and even with this aid, the book will scarcely be intelligible without some previous knowledge.

It is very much to be regretted that the committee has not seen its way to give some indication of the process by which the figures have been conjecturally deciphered, and to enable us to assign the degree of trustworthiness that can be placed on the suggested readings. This information is the more necessary, because research on Maya hieroglyphs is confined to a few experts, and the explanations that are now accepted cannot be regarded as final. We may confidently assert that these MSS. to some extent represent encyclopædias of astronomical or astrological lore, but, at the same time, it must be admitted that they include subjects of very diverse origin, the meaning of which is still obscure.

[1] Papers of the Peabody Museum of American Archæology and Ethnology, Harvard University. Commentary on the Maya Manuscript in the Royal Public Library of Dresden, by Dr. Ernst Förstemann. Translated by Miss Selma Wesselhoeft and Miss A. M. Parker. (Cambridge, Mass.: Published by the Museum, 1906.)

The key of the whole is the Tonalamatl. This is a period of time, determined by the combination of the numerals 1–13, with twenty different signs indicating as many days, consequently giving rise to a period of $20 \times 13 = 260$ days. The number 20 was the base of the ancient Mexican numerical system, and it was natural that for the measurement of time a count of twenty days should form the first unit of a higher order. The 13 is not so easily explained. Apparently it may be compared with a period analogous to our week. Such a period was but little suited for chronological purposes, since it was neither directly based on astronomical observation nor was it the expression of any uniform recurring motion in time. Yet, by its divisions and references to natural objects, such a calendric system was destined to become a useful artifice in the hands of the priestly caste for supporting forecasts and giving force to divination. Consequently, the chronological importance of the MS. merges into the astrological, and we find mixed up with the pictures figures representing gods, one of whom is delineated no less than 141 times, and several others who recur with greater or less frequency. It seems not impossible, therefore, that hidden under these symbols we have the essential part of the religious conception of the Maya peoples in a tolerably complete form; but, unfortunately, any connection between the figure of the god and the principle it represents remains vague and undetermined. The accounts of the Spanish authors regarding the mythology of the Mayas correspond very slightly with these figures of gods, and since all other conjectures respecting their significance are very dubious, the deities can only be safely and temporarily defined by alphabetical designations. Dr. Paul Schellas suggested this method of distinguishing, without describing, any particular deity, and this plan has been wisely followed by Dr. Förstemann in his commentary.

We may now ask whether the planets have been identified with greater certainty? The first reference to a planet is made in connection with "an inverted figure of a person in a squatting attitude, the head surrounded by stars, and a sign on the back, which may be a suggestion of the Sun glyph. In this figure I see the planet Mercury, and I believe that the planet's retrogression (which lasts 17–18 days) or disappearance into the light of the Sun during this week is the subject of this passage." The evidence, to those unused in the exercise of a vivid imagination in such matters, does not seem overpoweringly strong. The retrograde motion of Mercury, though variable in length, has a longer duration than seventeen to eighteen days. There is the suggestion of forced agreement here, but if we are to understand the time during which the planet remained invisible between the evening and the morning appearance, the construction is not impossible. But if it were the intention of the scribe to record such phenomena, it is difficult to understand why such symbols do not occur with some approach to regularity.

The references seem to be a little less obscure in the case of Venus. The author exhibits a series of numbers the law of formation of which, unfortunately, is not given in this treatise, which indicate that the Mayas were aware of the approximate equality of five synodic periods of Venus to eight solar years. Assuming the length of the solar year as 365 days, and the synodic period of Venus 584 days, 2920 days include both periods. This number occurs repeatedly. The author takes a further step, which also seems warranted. In a manner comparable with that by which the cycle of 7980 Julian years is determined, he proposes to bring in the Tonalamatl of 260 days by connecting it with the number 37,960 days. This number occurs in various combinations, and is equal to 146×260 (Tonalamatl), 104×365 (solar year), 65×584 (Venus, synodical period). This combination is sufficiently remarkable, and still more noticeable is the recurrence of higher numbers running into millions, in which it seems possible to trace this factor. But a very rigorous examination of the manner in which these numbers are formed is necessary before it can be concluded that they bear but one interpretation. It must also be remembered that the synodic period of Mars, taken at 780 days, is equal to precisely three Tonalamatls.

But if the instances of allusion to planetary periods are